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The Hamburg Quasar Monitoring program (HQM) at Calar Alto.* II. Lightcurves of weakly variable objects

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Abstract. — HQM is an optical broad-band photometric monitoring program carried out since Sept. 1988. We use a CCD camera equipped to the MPIA 1.2 m telescope. Fully automatic photometric reduction relative to stars in the frames is done within a few minutes after each exposure, thus interesting brightness changes can be followed in detail. The typical photometric error is 1–2 % for a 17.5 mag quasar. We here present lightcurves already evaluated but not shown in Paper I. We also discuss existing literature data.

Key words: quasars: general — techniques: photometric

1. Introduction

In this paper, being the second one in a series, we show some additional lightcurves for quasars which were *not* known to be optically violent variables prior to our program and for which measurements exist sufficiently spread over a time-span $\gtrsim 2$ yr. Some interesting properties of these quasars are given in Table 1 of Borgeest & Schramm (1993, hereafter Paper I); Table 4 of Paper I lists values of some reasonable parameters through which the lightcurve shapes can be quantified. We also give there the results of POSS photometry carried out to obtain indications for variability on a longer timescale.

For HQM, we use a CCD camera which was equipped with different chips, in 1988 with an RCA 15μ chip (640×1024, pixel size 0.315″) and later various, but similar, coated GEC 22μ chips (410×580, pixel size 0.462″). We measure the quasar fluxes through a standard Johnson R broad-band filter relative to stars included in the frames. The data reduction is carried out automatically, immediately after the observation, on a μVAX 3200 workstation. The software package "HQM" has been developed in Hamburg (for a short description see Paper I); it is much faster than standard image processing software. A 0.01 mag accuracy (in relative photometry) in the lightcurve of a $\sim$ 17.5 mag quasar can be reached in this way also for "non-photometric" conditions with a typical exposure time of 500 s.

Extensive monitoring programs which contain weakly variable quasars have been carried out by several investigators: Monitoring data obtained until 1973 are reviewed and critically discussed by Grandi & Tifft (1974, hereafter GT74). Lloyd (1984, hereafter L84) reports on lightcurves of 36 radio sources from the Herstmonceux Optical Monitoring program for the period 1966-1980 (see also Tritton & Selmes 1971, hereafter TS71; Selmes et al. 1975, hereafter STW). At the Rosemary Hill Observatory more than 200, mostly radio-selected quasars were monitored since 1968, however not all objects over the total period (Pica et al. 1980, hereafter PPSL; Pica & Smith 1983, hereafter PS83; Smith et al. 1993, hereafter SNLC, and Refs. therein). Another program was carried out at the Asagio Observatory (e.g. Barbieri et al. 1979, hereafter BRZ) over the period 1967 to 1977. Lightcurves of many bright quasars have been obtained from the Harvard historical plate collection (e.g. Angione 1973, hereafter A73) spanning periods of up to 100 years. Netzer & Sheffer (1983, hereafter NS83) compared the 1981 and $\sim$1950 POSS magnitudes of 64 optically selected UM quasars. Moore & Stockman (1984, hereafter MS84) have collected a catalog of the observational properties of 239 quasars, including variability data. More recent publications on optical variability of quasars generally deal with violently variable sources.

2. Discussion of the lightcurves

PHL 658 (0003+158) has also been found in large area optical and X-ray surveys. The historical lightcurve shows no features (the standard deviation of the data

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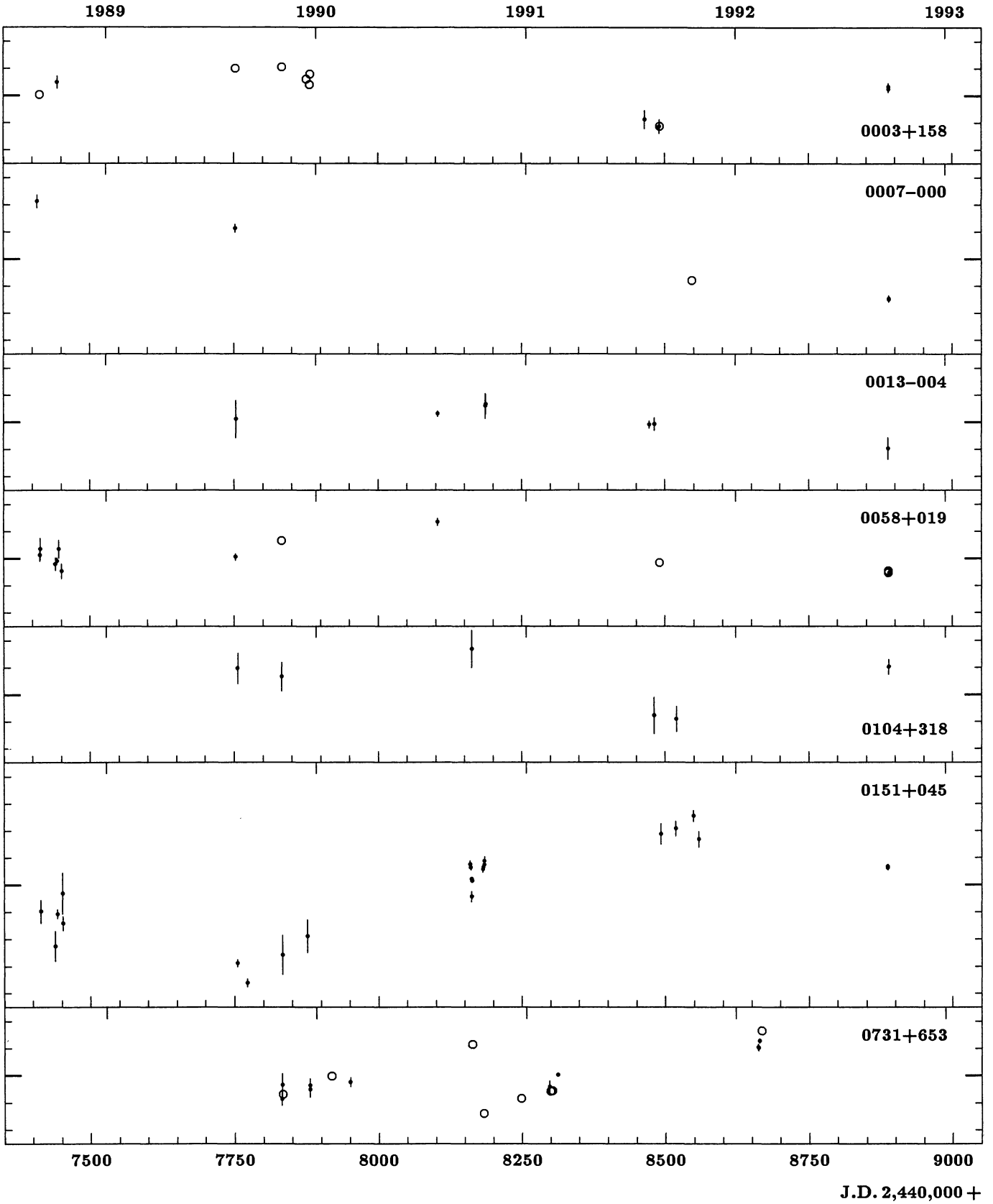


Fig. 1. HQM-lightcurves in the R-band. Dashes on the vertical axes represent 0.1 mag steps. Plotted are variations $\Delta R = R_0 - R$; the reference magnitude R_0 is indicated by thick dashes. Measurements obtained under bad atmospheric conditions or those with only one reference star are shown by open circles; reliable error bars can in these cases not be given

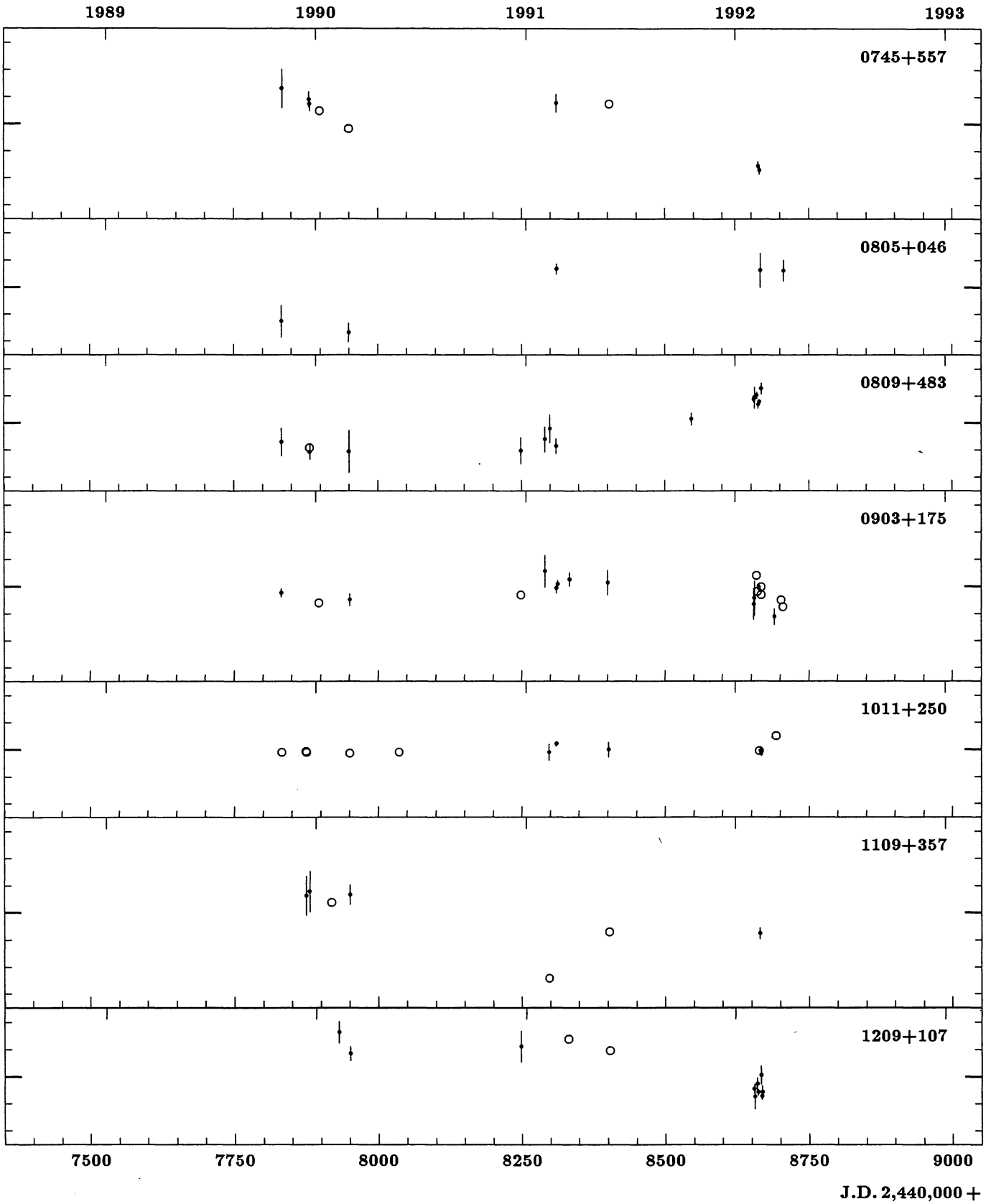
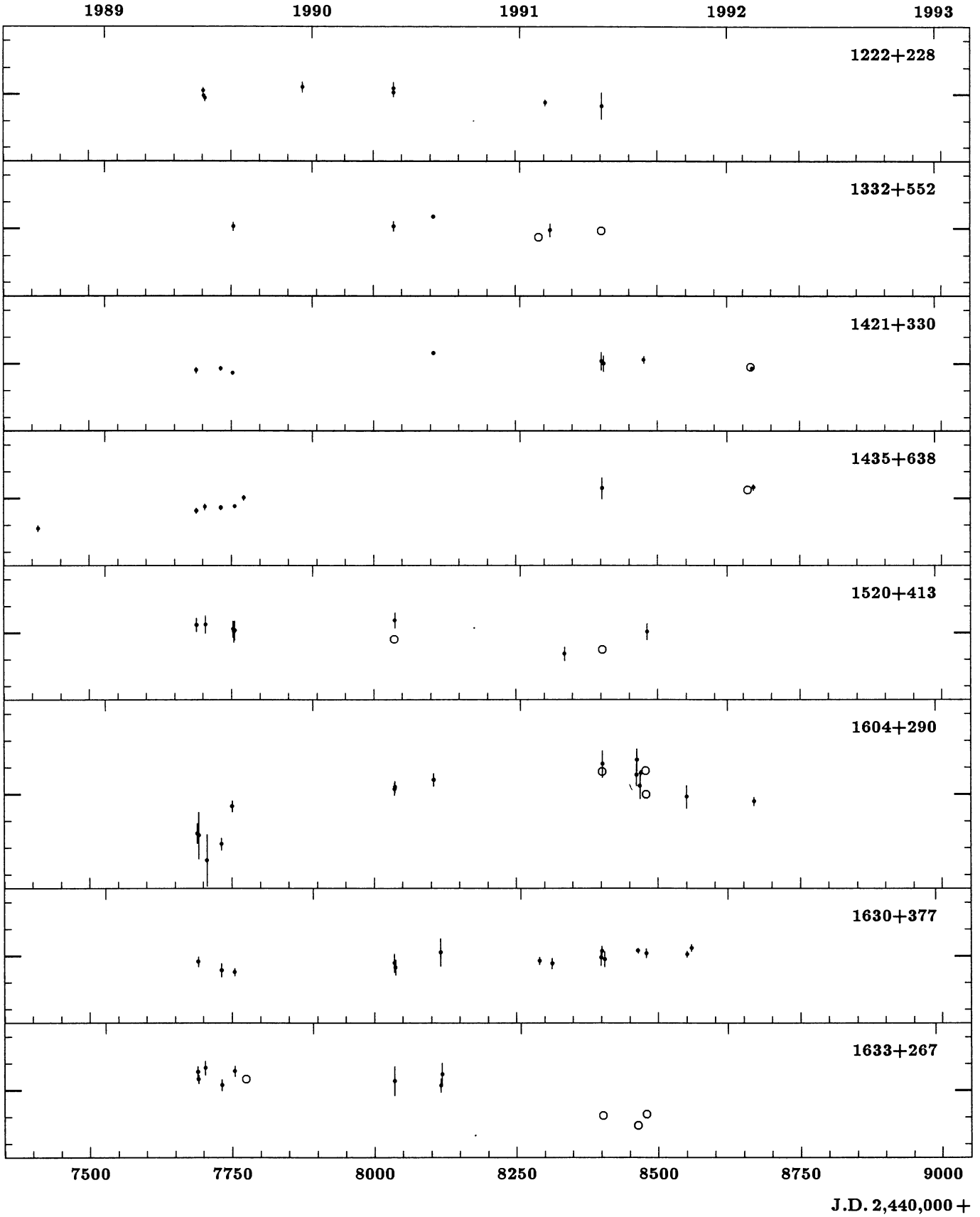


Fig. 1. continued



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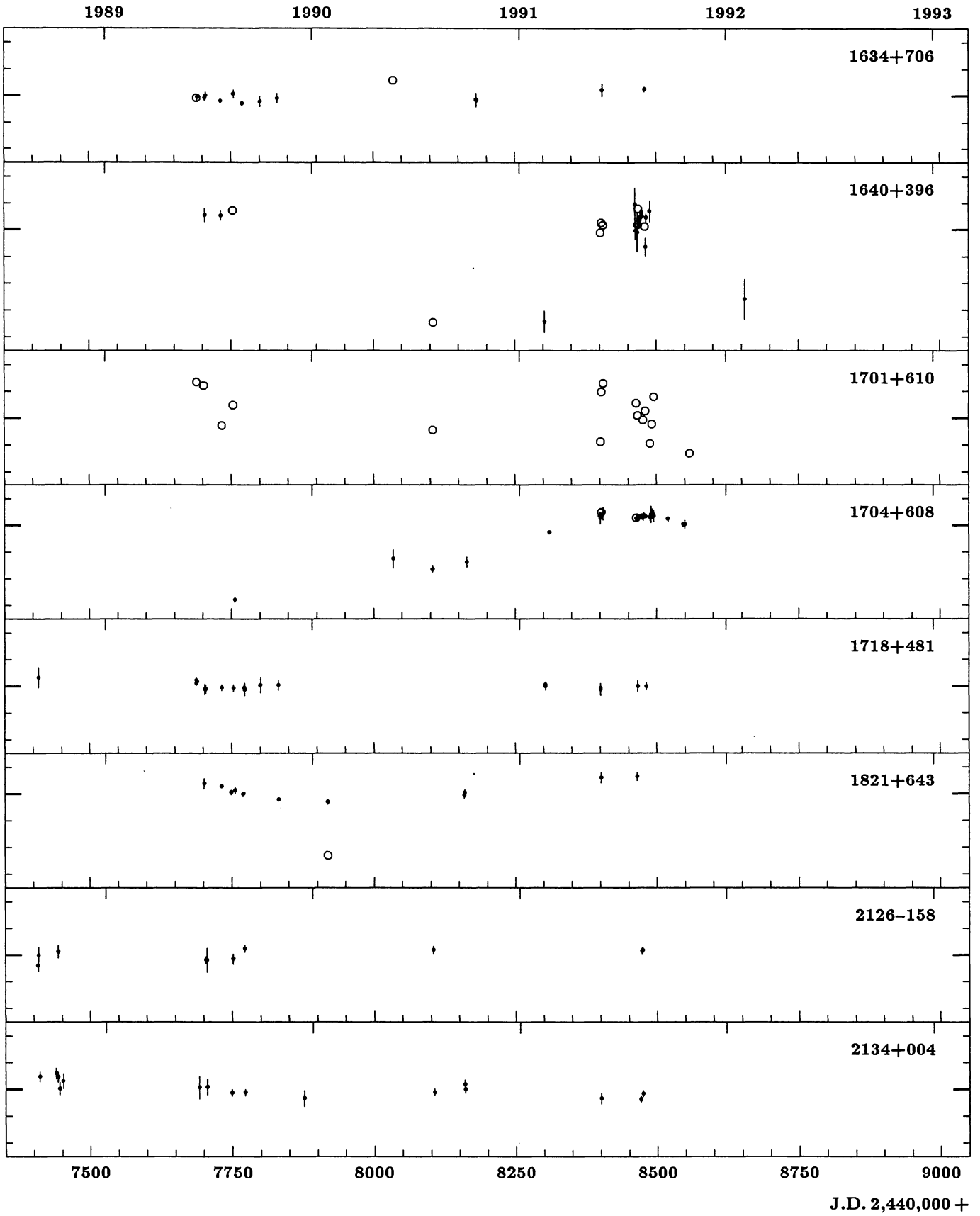

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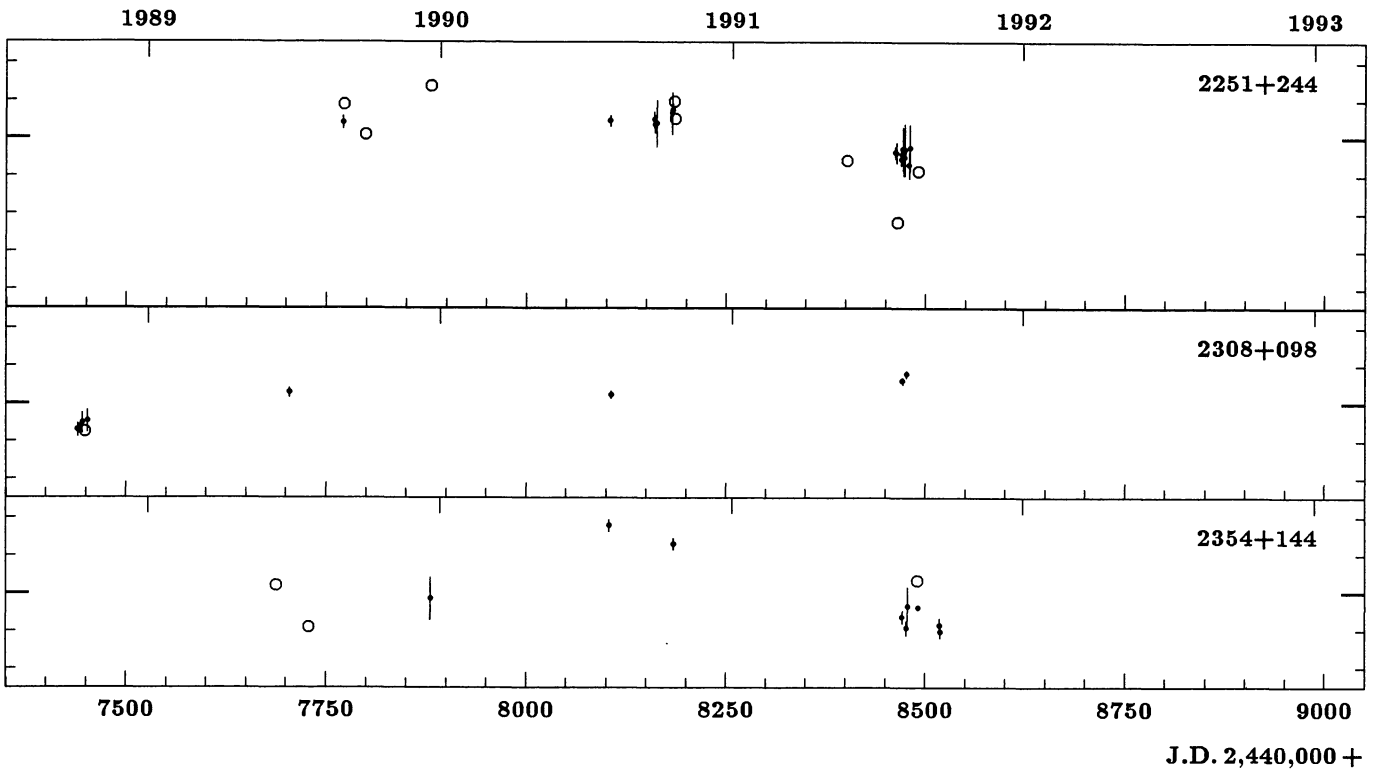

Fig. 1. continued

is $\sigma = 0.16$ mag, A73). Between 1966 and 73, a (monotonic but not linear) 0.5 mag increase has been measured (TS71, STW, BRZ); in addition, BRZ report the detection of three flares, not confirmed by others. L84 found $\sigma = 0.062$ mag (1966-80), PS83 found $\sigma = 0.12$ mag (1970-78). SNLC report a long-term brightening ($\Delta B \simeq 0.4$) between 1982 and 1991 as well as short-term variations around this trend. Our data have $\sigma = 0.081$ mag (1988-92); there are no signs of short-term variations. Our POSS photometry suggests variability of some 0.1 mag.

UM 208 (0007−000). NS83 found no significant long-term variation. In our survey, the object shows a relatively large amplitude ($\Delta R = 0.4$ mag, $R' \simeq 0.1\,\mathrm{mag\,yr^{-1}}$).

UM 224 (0013−004) also showed no long-term variation (NS83). Our observations yield weak variability of marginal significance. Pica et al. (1980) report on a faint red companion of the quasar.

PHL 938 (0058+019) was almost constant ($\sigma = 0.13$ mag, PS83) during the '70s, compatible with our data.

1E 0104+318. For this BAL quasar, Gioia et al. (1986) reported a variability of $\Delta R \simeq 0.5$ mag during the period 1982–84. The HQM lightcurve for this faint quasar is not well sampled; indications for weak variability are only tentative. Our POSS photometry indicates moderate variations on very long timescales.

PHL 1226 (0151+045) showed the largest variation ($\Delta V = -1.22 \pm 0.2$ mag) in the survey of NS83; PS83 found no significant variability ($\sigma = 0.13$ mag). Our lightcurve shows relatively strong variations.

0731+653 (W1). The HQM lightcurve is dominated by data points obtained under poor conditions; however, an overall increase in brightness is obvious from the few good exposures. On our best CCD frames, three faint galaxies are seen 3″, 10″ and 18″ from the quasar.

1E 0745+557. There are no variability data in the literature. The HQM measurements indicate a steady fading; only data obtained under poor conditions deviate slightly from this trend.

4C 05.34 (0805+046). During the Rosemary Hill program (PS83), the object was only marginally variable with $\sigma = 0.114$ mag (for more recent data see SNLC). The HQM lightcurve is possibly undersampled so that only an overall brightening can be stated.

3C 196 (0809+483). All literature data indicate only marginal variability (GT74). The HQM lightcurve is well described by a second order polynomial.

0903+175. There are no variability data in the literature. Our measurements indicate only variations near the detection limit; the percentage of observations carried out under poor conditions is relatively high.

Ton 490 (1011+250). MS84 report, without more details, a 1.3 mag brightness change. The HQM data are consistent with a constant flux.

1E 1109+357. There are no variability data in the literature. The HQM data are sparse and partly obtained under poor conditions; only an overall fading is obvious.

1209+107 (KP 9). There are no variability data in the literature. The HQM data show a steady decline of $\simeq$

$0.1\,\mathrm{mag\,yr^{-1}}$.

Ton 1530 (1222+228). There are no variability data in the literature. Our lightcurve seems to show very weak long-term variations at the detection limit. On our deepest frames, there is an excess of faint galaxies inside 30″.

4C 55.27 (1332+552). MS84 report, without more details, a 1.9 mag brightness change. From the HQM data, there are no indications for variability; whereas our POSS photometry shows a significant change on the very long scale. On deep images, a number excess of faint galaxies inside 30″ around the quasar is seen; additionally, a probably interacting pair of galaxies (tidal arm) of totally $R \simeq 15.5$ lies 68″ SW and a single, relatively bright ($R \simeq 14.0$) galaxy 114″ SW.

Mkn 679 (1421+330). There are no variability data in the literature. The HQM data seem to indicate very weak long-term variations at the detection limit.

S4 1435+638. There are no variability data in the literature. The HQM lightcurve is not well sampled. Obvious is only a slight brightening. Our POSS photometry indicates a large variation ($\Delta R_{40} \simeq 1.6$).

1520+413 (SP 43). There are no variability data in the literature. Our measurements indicate weak variations, determined however by only few data points.

1604+290 (KP 63). There are no variability data in the literature. Our measurements show that the quasar is relatively strongly variable; the lightcurve is well fitted by a second order polynomial. On our best frames, a number excess of faint galaxies inside 30″ around the quasar is seen; probably, a compact cluster of galaxies lies about 1′ NE.

PG 1630+377. There are no variability data in the literature. Our lightcurve shows very weak variations at the detection limit.

1633+267 (KP 83). There are no variability data in the literature. There is an overall decrease in the HQM fluxes; the most recent data are however obtained under poor conditions.

PG 1634+706. There are no variability data in the literature. Our lightcurve is consistent with a constant flux.

1E 1640+396 . There are no variability data in the literature. Our measurements show that the object varies on a timescale comparable with the timelags between the observing campaigns.

1701+610. There are no variability data in the literature. There is only one useful reference star in the CCD frame so that no error calculation could be made for the HQM data. The scatter in the flux values is therefore possibly not real.

3C 351 (1704+608). The historical lightcurve between 1895 and 1965 measured by A73 shows variations with $\sigma = 0.25$ mag; a 0.9 mag change between two nights was reported. Later brightness values (L84, Angione et al. 1981, BRZ, Kinman 1968; Lü 1972) indicate only low amplitude variations. The most recent photometry shows variability of some 0.1 mag between 1983 and 1986 (Corso et al. 1985, 1986, 1987). The Rosemary Hill data (SNLC) suggest a brightness increase since 1988. The HQM lightcurve is well fitted by a third order polynomial; a maximum occurring in summer 1991 is covered by a large number of measurements. On our deepest exposures, an enhancement of faint galaxies is seen within a few arcsec around the quasar.

PG 1718+481. There are no variability data in the literature. The HQM lightcurve is perfectly flat.

E 1821+643. There are no variability data in the literature. The HQM data for this bright quasar have very low errors. The lightcurve is well described by a second order polynomial; only one point, obtained under poor conditions, deviates from the best fit. POSS photometry indicates variations on the very long scale, too. Its a funny mistake that Monk et al. (1986) quote the existence of a foreground galaxy for E 1821+643 (cf. Hewitt & Burbidge 1987); actually, one has here the very rare case of an angular coincidence between a quasar and a planetary nebula (Kohoutek, private communication).

PKS 2126−158. There are no variability data in the literature. Our photometric measurements are consistent with a constant flux although there is slight evidence for a weak brightening.

PHL 61 (2134+004). L84 found the quasar almost constant between 1977 and 1979. The historical lightcurve of Gottlieb & Liller (1978) between 1922 and 1954 shows two very bright outbursts ($B \simeq 14.8$ mag), compared to a usual level of $B \simeq 17.5$ mag. The mm-radio lightcurve between 1982 and 1986 measured by Fiedler et al. (1987) shows significant variability in the percent range. At lower radio frequencies the object was also found to be variable during the period 1972–74 (Wardle et al. 1981). The only significant feature in our optical data is a linear fading by $\sim 0.015\,\mathrm{mag\,yr^{-1}}$.

4C 24.61 (2251+244). There are no variability data in the literature. A large fraction of the HQM data was obtained under poor conditions. The better data are well fitted by a second order polynomial.

4C 09.72 (2308+098). BRZ searched for variability during 1973/74, with a negative result. The HQM lightcurve is not well sampled so that only an overall brightening can be stated.

PKS 2354+144. This object was included in the early Rosemary Hill sample; Folsom et al. (1971) reported only moderate variability with $\Delta B \lesssim 0.5$ mag. The HQM data are in agreement with this; whereas our POSS photometry indicates a larger variation on the very long scale.

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